



[Document Name] Specification

[Title of the Invention] An organic electroluminescence element and its manufacturing method

[Detailed Description of the Invention]

5 [Field of Technology of the Invention]

[0001] The present invention relates to an organic electroluminescence element which is excellent in the output efficiency of light generated in the organic luminous layer.

[Prior Art Technology]

10 [0002] Because the organic electroluminescence displays which are equipped with organic electroluminescence elements (elements having an organic luminous layer between the cathode and the anode) corresponding to the respective pixels have high brightness with spontaneous light, can be driven with direct current at low voltage, have a high speed response, and have light generated by a solid organic  
15 film, being excellent in display performance and enabling thickness reduction, weight reduction, and electricity consumption reduction, they are expected to replace liquid crystal displays in the future.

[0003] In an organic electroluminescence display, a large number of pixels consisting of organic electroluminescence elements are placed in a matrix consisting  
20 of rows and columns falling at right angles. As the driving methods of organic electroluminescence displays, there are the active matrix method and the passive matrix method.

[0004] In the passive matrix method, patterning is done by letting one of the two electrodes sandwiching an organic luminous layer correspond to the row and the  
25 other to the columns, and a pixel consisting of an organic electroluminescence element is formed in the position where the two electrodes overlap. Also, because the row electrode and the column electrode correspond to the scanning line and the data line and the ON state is made by selecting one row electrode and one column electrode, only the pixel in the position where both electrodes are simultaneously in  
30 the ON state emits light.

[0005] On the other hand, in the active matrix method, one electrode (the pixel electrode) and the organic luminous layer are formed in a matrix shape, the other electrode is formed over the whole surface of the display as the common electrode,

and each pixel is equipped with a driving transistor and capacity. Therefore, an active matrix type organic electroluminescence display enables higher definition at high brightness, thus being able to deal with increases in gray scales and display size.

[0006] An explanation is provided hereafter of an example of active matrix type organic electroluminescence displays proposed heretofore, with reference to Figs. 9~11,. Figure 9 is a partial plane view, showing one pixel and its driving element etc. arranged surrounding the pixel. Figure 10 shows a circuit for driving one pixel of the display. Figure 11 shows a cross section of the A-A line in Fig. 9.

[0007] As shown in Figs. 9 and 10, in this active matrix type organic electroluminescence display, each pixel consisting of an organic electroluminescence element E is equipped with a switching transistor 13, a capacity 14, and a driving transistor 15. These elements are connected to the driving circuit via a scanning line 10, a signal line 11, and the common line 12. In this active matrix type organic electroluminescence display, a pixel is selected by a switching transistor 13, and an organic electroluminescence element E which is the pixel which permits the emission of light at a preset brightness by a driving transistor 15.

[0008] As shown in Fig. 11, on a glass substrate 1 of this display, after each driving element including a signal line 11 and the driving transistor 15 are formed, an insulating layer 16 is formed. In this insulating layer 16, a contact hole 16a is formed on the position of the source/drain electrode 15a of the driving transistor 15. Also, formed on the insulating layer 16 is a bank 17 that divides the substrate surface into pixels.

[0009] In the pixel area divided by this bank 17, an anode layer (light-transmissive electrode layer) 3 and an organic luminous layer 4 are formed. Further, on the whole substrate above it, a cathode layer (light-reflective electrode layer) 5 is formed. Here, when forming the anode layer 3, the contact hole 16a is filled with the component material (conductor) of the anode layer 3, connecting the source/drain electrode 15a and the anode layer 3. In Fig. 9, a conductor (connecting plug) filled in this contact hole 16a is indicated by the code "18".

[0010] In order to reduce consumption of electricity by an organic electroluminescence display, irrespective of the difference in driving methods, improving luminous efficiency of the organic electroluminescence element is effective. The method to do so is to improve the raw materials and their combination

in each layer of the hole transport layer and/or the electron transport layer between the organic luminous layer and electrode layer.

[0011] Also, as shown in Fig. 12, light generated in the organic luminous layer 4 radiates in all directions. Then, the light irradiated straight toward the side of the glass substrate 1A and a part of the light reflected by the interface between the light-reflective cathode layer 5 and the organic luminous layer 4 emerge toward the side of the glass substrate 1A. As shown in the figure, in a cumulate body where the whole cumulate surface is flat, light H irradiated in parallel with the cumulate surface of the cumulate body S goes toward the end surface of the organic luminous layer 4 (the surface in contact with the inner wall of the bank 17 in Fig. 11) and does not emerge toward the side of the glass substrate 1A.

[0012] As a result, outgoing efficiency of light generated in the organic luminous layer 4 (ratio of light quantity emerging to the side of the glass substrate 1A to the total emission quantity in the organic luminous layer 4) is said to be about 20 % for example. Therefore, increasing outgoing efficiency of light generated in the organic luminous layer 4 becomes important for reducing consumption of electricity by the organic electroluminescence display.

[0013] In Pat Dis Hei 11-214163 Public Report, it is described that outgoing efficiency of light generated in an organic luminous layer is increased by reflecting in the direction perpendicular to the substrate surface the light outgoing in a horizontal direction relative to the substrate surface by installing many holes in one electrode layer and installing slopes on the other electrode utilizing these holes.

[Problem overcome by the Invention]

[0014] However, in the method described in the public report, because electrode area actually decreases by installing holes in one electrode layer, the numerical aperture of the organic electroluminescence display decreases. Decrease in numerical aperture leads to a decrease in luminous efficiency. Therefore, the method described in the public report has room for further improvement in reducing the consumption of electricity of the organic electroluminescence display.

[0015] It is an objective of the present invention to increase the output efficiency of light generated in an organic luminous layer of an organic electroluminescence element.

[Problem Resolution Means]

[0016] In order to solve the problem, the present invention, being an organic electroluminescence element equipped with a cumulate body having a cathode layer, an anode layer, and one or more organic thin film layer containing an organic luminous layer placed between the cathode layer and the anode layer, provides an organic electroluminescence element characterized by the fact that the cathode layer and the anode layer have slopes.

[0017] Because light generated in the organic luminous layer of such an organic electroluminescence element is reflected by one of the slopes of the cathode layer or the anode layer, such an organic electroluminescence element has a structure for light guided out to the observation side efficiently.

[0018] Here, as the raw material composing the anode layer for example, ITO, platinum, nickel, iridium, and palladium can be used, and in some cases it can be a cumulate film containing the materials. As the raw material composing the cathode layer for example, gold, magnesium-silver, lithium oxide-aluminum, and lithium fluoride-aluminum can be used, and in some cases, it can be a cumulate film containing the materials such as a cumulate film of lithium fluoride and aluminum or a cumulate film of lithium oxide and aluminum. If the electrode film thickness and material are appropriately selected to make it a light-transmissive electrode, light can be extracted from either side of the cathode layer or the anode layer.

[0019] For example, according to the organic electroluminescence element, at least a part of light generated in the organic luminous layer and irradiated in parallel or almost in parallel to the cumulate surface of the cumulate body is mainly reflected by a slope on the boundaries between the light-reflective electrode layer and the organic luminous layer and goes out in the light-transmissive electrode layer side.

[0020] Because area of the both electrode layers and the organic luminous layer of the organic electroluminescence element can be increased by installing slopes, it is fit for increasing emission quantity compared to the case where the whole cumulate surface is flat.

[0021] If slopes are made on the rim sections of the pixels, light generated in the pixel section becomes more easily reflected by the slopes made on the rim sections, making the light outgoing efficiency higher. Therefore, in the organic electroluminescence element of the present invention, it is preferable that the slopes be formed on the rim sections within the area.

[0022] In the parallel irradiated light, if the quantity of light reflected by the slopes on the boundaries becomes larger, the higher the projection of the organic luminous layer by the slopes. Therefore, in the organic electroluminescence element of the present invention, it is preferable that the protruding height of the organic luminous layer by the slopes be higher than the thickness of the organic luminous layer and larger than the total of the thickness of the light-transmissive electrode layer and the thickness of the organic luminous layer.

[0023] In the organic electroluminescence element of the present invention, it is preferable that plural number of the slopes be formed in a uniform arrangement in the surface. By so doing, there is greater uniformity in the area of the quantity of light that is reflected by the slopes of the boundaries and that goes out to the light-transmissive electrode layer side.

[0024] In the organic electroluminescence element of the present invention, the slopes can be formed by making projections made of insulating material on the substrate composing the cumulate body. Also, they can be formed by making the electrode layer formed on the substrate side where the cumulate body is formed in the shape having convex sections corresponding to the slopes.

[0025] The present invention also provides, as a method of manufacturing the organic electroluminescence element of the present invention, a method characterized by being equipped with the following (1)~(5).

- (1) A step of forming an insulating film on a substrate where the cumulate body is formed.
- (2) A step of forming projections made of insulating material on the parts corresponding to the slopes on the substrate by patterning the insulating film,.
- (3) A step of forming one electrode layer (an anode layer or a cathode layer) on the substrate where the projection is formed.
- (4) A step of forming an organic luminous layer on the electrode layer.
- (5) A step of forming the other electrode layer (a cathode layer or an anode layer) on the organic luminous layer.

[0026] In the method of the present invention, the projection is preferable formed in the following processes (21)~(23).

- (21) A step of forming a first insulating film on the substrate.

(22) A step of forming on the first insulating film a second insulating film made of a different material from the first insulating film.

(23) A step of patterning the second insulating film.

[0027] The present invention also provides a method characterized by being  
5 equipped with the following (6)~(8) as a method of manufacturing the organic electroluminescence element of the present invention.

(6) A step of forming one electrode layer (an anode layer or a cathode layer) on the substrate where the cumulate body is formed so that it is placed on the whole surface of the area and has convex sections on the parts corresponding to the slopes.

10 (7) A step of forming an organic luminous layer on the electrode layer.

(8) A step of forming the other electrode layer (a cathode layer or an anode layer) on the organic luminous layer.

[0028] In this method, if one of the electrode layers (the anode layer or the cathode layer) is a light-transmissive electrode layer, the electrode layer can be formed  
15 in the following processes of (61)~(63).

(61) A step of forming on the substrate a first thin film made of a light-transmissive, conductive material by spluttering.

(62) A step of forming a second thin film made of a light-transmissive, conductive material by forming a coating of liquid containing light-transmissive, conductive  
20 materials on the first thin film and then removing the solvent in the coating.

(63) A step of forming convex sections by patterning and then baking the second thin film.

[Brief Explanation of Drawings]

[Fig. 1]

25 [0029] A plane view showing the interior of one pixel region of an organic electroluminescence display of the first to third embodiments.

[Fig. 2]

A drawing showing a configuration of the organic electroluminescence display of the first embodiment, corresponding to the cross-sectional view of the A-A line in  
30 Fig. 1.

[Fig. 3]

A drawing showing a configuration of the organic electroluminescence display of the second embodiment, corresponding to the cross-sectional view of the A-A line in Fig. 1.

[Fig. 4]

5 A drawing showing a configuration of the organic electroluminescence display of the third embodiment, corresponding to the cross-sectional view of the A-A line in Fig. 1.

[Fig. 5]

10 A plane view showing the interior of one pixel region of an organic electroluminescence display of the fourth embodiment.

[Fig. 6]

A drawing showing a configuration of the organic electroluminescence display of the fourth embodiment, corresponding to the cross-sectional view of the A-A line in Fig. 5.

15 [Fig. 7]

A drawing showing an example of the arrangement method for uniformly arranging plural number of slopes within the surface of one pixel region, where (a) is a plane view, and (b) is a cross-sectional view of the B-B line in (a).

[Fig. 8]

20 A drawing showing an example of the arrangement method for uniformly arranging plural number of slopes within the surface of one pixel region, where (a) is a plane view, and (b) is an expanded view showing a part of (a).

[Fig. 9]

25 A partial plane view showing an example of the conventional active matrix type organic electroluminescence display which shows one pixel and the driving elements etc. arranged around the pixel.

[Fig. 10]

A plane view showing an example of the conventional active matrix type organic electroluminescence display which shows a circuit for driving on pixel.

30 [Fig. 11]

A cross-sectional view of the A-A line in Fig. 9.

[Fig. 12]

A cross-sectional view of a conventional organic electroluminescence element, which is a drawing for explaining the behavior of light generated in the organic luminous layer.

[Embodiments of the Invention]

5           **[0030]**   Explanations are given hereafter of embodiments of the present invention.

[First Embodiment]

10           **[0031]**   Using Figs. 1 and 2, an explanation is given on an organic electroluminescence display corresponding to the first embodiment of the organic electroluminescence element of the present invention. Figure 1 is a plane view showing an area (an area corresponding to the pixel region divided by the bank 17 in Fig. 11) of the organic electroluminescence display, and Fig. 2 corresponds to the cross sectional view of the A-A line in Fig. 1. The code 1A in Fig. 2 indicates a glass substrate in the state just before a cumulate body S is formed (a state where many kinds of driving elements are formed on the glass substrate and the bank 17 is formed).

15           **[0032]**   On the glass substrate 1A, a cumulate body S is formed via a projection 2 made of a light-transmissive insulating material. This projection 2 is formed by forming a thin film made of light-transmissive materials such as silicon dioxide ( $\text{SiO}_2$ ) and silicon nitride ( $\text{Si}_3\text{N}_4$ ) on the glass substrate 1A by the plasma CVD method or the sputtering method at 400 nm in thickness for example and then patterning the thin film. This patterning is done by forming a resist pattern on the thin film and then etching it.

20           **[0033]**   By this patterning, rim sections of the pixel areas of the thin film are removed by the specified width so that four sides of the projection 2 become slopes 61 in a tapered shape that becomes narrower in the direction of going away from the glass substrate 1A. As the result, four slopes 61 composing the sides of the projection 2 are formed in the rim section of the pixel region. Here, in Fig. 2 which is the cross-sectional view, only two slopes 61a and 61b are displayed.

30           **[0034]**   A cumulate S consists of an anode layer (a light-transmissive electrode layer) 3 made of ITO ( $\text{In}_2\text{O}_3\text{-SnO}_2$ ), an organic luminous layer 4, and a metallic cathode layer (a light-reflective electrode layer) 5. Thin films composing these layers 3~5 are formed one by one on the glass substrate 1A after a projection 2 is



formed. By this, slopes 62~64 are formed on the section of four slopes 61 of the projection 2 on each of the layers 3~5, too. These slopes 62~64 protrude from the anode layer 3 side to the cathode layer 5 side. Also, these slopes 62~64 are formed on the rim section side of the pixel region.

5           **[0035]** Here, in Fig. 2 which is a cross-sectional view, only two slopes each 62a~64a and 62b~64b are displayed. In Fig. 1 which is a plane view, four slopes 64a~64d of the cathode layer 5 are displayed.

10           **[0036]** The anode layer 3 made of ITO is formed by the sputtering method for example. The organic luminous layer 4 is made, for example, in the two-layer structure having a hole transport layer in the anode layer 3 side or the three-layer structure having an additional electron transport layer in the cathode layer 5 side. The organic luminous layer 4 is formed by the vapor coating method etc. when using low polymer materials, and is formed by the spin coat method, the inkjet method, etc. when using high polymer materials.

15           **[0037]** The cathode layer 5 is, for example, by the vapor coating method etc. using aluminum (Al) with calcium (Ca) or magnesium (Mg), or materials containing alkali metals such as lithium (Li).

20           **[0038]** In this embodiment, the thickness of the anode layer 3 is set to 100 nm, the thickness of the organic luminous layer is set to 200 nm, and the thickness of the projection 2 is set to 400 nm which is larger than these total thickness 300 nm. By this, the protruding height of the organic luminous layer 4 by the slope 63 becomes larger than the total size of the thickness of the cathode layer 3 and the thickness of the organic luminous layer 4.

25           **[0039]** Therefore, according to the organic electroluminescence element of this embodiment, light H generated in the organic luminous layer 4 and irradiated in parallel to the cumulate surface of the cumulate body S is mainly reflected by the slope 63 on the boundary between the organic luminous layer 4 and the cathode layer 5 and goes out to the anode layer 3 side. By this, the outgoing efficiency of light generated in the organic luminous layer 4 to the anode layer 3 side can be increased  
30 without decreasing the numerical aperture. Here, by setting slope 63 to 45°, the quantity of light that is reflected by this slope 63 and goes out to the anode layer 3 side can be maximized.

[0040] Also, in this organic electroluminescence element, because both of the electrode layers 3 and 5 and the organic luminous layer 4 have slopes that exist over the whole surface in the pixel region, areas of the two electrode layers 3 and 5 and the organic luminous layer 4 increase and the emission quantity increases by that amount compared with organic electroluminescence elements equipped with cumulate bodies whose whole surface of the cumulate layer is flat.

[Second Embodiment]

[0041] Using Figs. 1 and 3, an explanation is given on an organic electroluminescence display corresponding to the second embodiment of the organic electroluminescence element of the present invention. Figure 1 is a plane view showing an area (an area corresponding to the pixel region divided by the bank 17 in Fig. 11) of this organic electroluminescence display, and Fig. 3 corresponds to the cross sectional view of the A-A line in Fig. 1. The code 1A in Fig. 3 indicates a glass substrate in the state just before a cumulate body S is formed (a state where many kinds of driving elements are formed on the glass substrate and the bank 17 is formed).

[0042] On this glass substrate 1A, a cumulate body S is formed via a projection 2 made of an insulating material different from the first insulating film 21 or the first insulating film 21. The first insulating film 21 is made of silicon nitride ( $\text{Si}_3\text{N}_4$ ), and the projection 2 is made of silicon dioxide ( $\text{SiO}_2$ ).

[0043] The first insulating film 21 is made by the plasma CVD method with a thickness of 100 nm for example. This projection 2 is formed by forming a silicon dioxide thin film (the second insulating film) with a thickness of 300 nm for example and then patterning this thin film. This patterning is done by forming a resist pattern on the thin film and then etching it with a fluorine-system etching liquid for example.

[0044] By this patterning, the rim sections of the pixel areas of the thin film are removed by a specified width so that four sides of the projection 2 become slopes 61 in a tapered shape that becomes narrower in the direction of going away from the glass substrate 1A. As the result, four slopes 61 composing the sides of the projection 2 are formed in the rim section of the pixel region. Here, in Fig. 2 which is the cross-sectional view, only two slopes 61a and 61b are displayed.

[0045] A cumulate S consists of an anode layer (a light-transmissive electrode layer) 3 made of ITO ( $\text{In}_2\text{O}_3\text{-SnO}_2$ ), an organic luminous layer 4, and a

metallic cathode layer (a light-reflective electrode layer) 5. Thin films composing these layers 3~5 are formed one by one on the glass substrate 1A after a projection 2 is formed. By this, slopes 62~64 are formed on the section of four slopes 61 of the projection 2 on each of the layers 3~5, too. These slopes 62~64 protrude from the anode layer 3 side to the cathode layer 5 side. Also, these slopes 62~64 are formed on the rim section side of the pixel region.

[0046] Here, in Fig. 2 which is a cross-sectional view, only two slopes each 62a~64a and 62b~64b are displayed. In Fig. 1 which is a plane view, four slopes 64a~64d of the cathode layer 5 are displayed.

[0047] Configuration and forming method of the layers 3~5 are the same as in the first embodiment except for setting the thickness of the organic luminous layer 4 to 100 nm. Namely, in this embodiment, the thickness of the anode layer 3 is set to 100 nm, the thickness of the organic luminous layer is set to 100 nm, and the thickness of the projection 2 is set to 300 nm which is larger than these total thickness 200 nm. Thus, the protruding height of the organic luminous layer 4 by the slope 63 becomes larger than the total size of the thickness of the cathode layer 3 and the thickness of the organic luminous layer 4.

[0048] Therefore, according to the organic electroluminescence element of this embodiment, light H generated in the organic luminous layer 4 and irradiated in parallel to the cumulate surface of the cumulate body S is mainly reflected by the slope 63 and goes out to the anode layer 3 side. By this, outgoing efficiency of light generated in the organic luminous layer 4 to the anode layer 3 side can be increased without decreasing the numerical aperture. Here, by setting slope 63 to 45°, quantity of light that is reflected by this slope 63 and goes out to the anode layer 3 side can be maximized.

[0049] Also, in this organic electroluminescence element, because both of the electrode layers 3 and 5 and the organic luminous layer 4 have slopes that exist over the whole surface in the pixel region, areas of the two electrode layers 3 and 5 and the organic luminous layer 4 increase and the emission quantity increases by that amount compared with organic electroluminescence elements equipped with cumulate bodies whose whole surface of the cumulate layer is flat.

[0050] Further, in this embodiment, formation of the projection 2 for forming slopes is done by forming continuously the first insulating film made of

silicon nitride and the second insulating film made of silicon oxide and then wet-etching the second insulating film with a fluorine-system etching liquid. The etching speed by fluorine-system etching liquid should be high with silicon oxide which is the material of the second insulating film and low with silicon nitride which is the material of the first insulating film..

[0051] Therefore, because the first insulating film becomes more resistant to overetching by etching with fluorine-system etching liquid of the second insulating film, the protruding height of the projection 2 can be easily made the same with the thickness of the second insulating film. Therefore, by forming the second insulating film to the same thickness with the protruding height of the projection 2, the protruding height of the projection 2 can be easily controlled.

[Third Embodiment]

[0052] Using Figs. 1 and 4, an explanation is given on an organic electroluminescence display corresponding to the third embodiment of the organic electroluminescence element of the present invention. Figure 1 is a plane view showing an area (an area corresponding to the pixel region divided by the bank 17 in Fig. 11) of this organic electroluminescence display, and Fig. 4 corresponds to the cross sectional view of the A-A line in Fig. 1. The code 1A in Fig. 4 indicates a glass substrate in the state just before a cumulate body S is formed (a state where many kinds of driving elements are formed on the glass substrate and the bank 17 is formed).

[0053] In this embodiment, slopes 62~64 of both electrode layers 3 and 5 and an organic luminous layer 4 are formed by making an anode layer (a light-transmissive electrode layer) 3 made of ITO ( $\text{In}_2\text{O}_3\text{-SnO}_2$ ) in a shape having a convex section 32 corresponding to the slopes. This anode layer 3 is formed in the following method.

[0054] First, the first ITO thin film 31 is made 1A by the sputtering method on the glass substrate with a thickness of 100 nm. Next, on the first ITO thin film 31, a coating is formed by the spin coat method with a liquid made of an organic acid containing indium (In) and tin (Sn) (a liquid containing light-transmissive, conductive materials).

[0055] Next, by heating it at 100 °C, solvent in this coating is removed and the second ITO thin film is formed.

[0056] Next, by patterning and then baking the second ITO thin film, a convex section 32 is formed. These processes are done so that the thickness of the convex section 32 after baking becomes 200 nm for example. Also, this patterning is done after forming a resist pattern on the second ITO thin film and then by wet-  
5 etching it using an aqua-regia system etching liquid for example.

[0057] By this patterning, rim sections of the pixel areas of the second ITO thin film are removed by the specified width so that four sides of the convex section 32 made of an ITO thin film become slopes 62 in a tapered shape that becomes narrower in the direction of going away from the glass substrate 1A. As the result,  
10 four slopes 62 composing the sides of the convex section 32 are formed in the rim section of the pixel region. Here, in Fig. 4 which is the cross-sectional view, only two slopes 62a and 62b are displayed.

[0058] On an anode layer 3 having this convex section 32, an organic luminous layer 4 and a metallic cathode layer (a light-transmissive electrode layer) 5 are formed one by one. By this, slopes 63 and 64 are formed on the section of four slopes 62 of the convex section 32 on the organic luminous layer 4 and the cathode layer 5, too. These slopes 62~64 protrude from the anode layer 3 side to the cathode layer 5 side. Also, these slopes 62~64 are formed on the rim section side of the pixel region.  
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[0059] Here, in Fig. 4 which is a cross-sectional view, only two slopes 63a, 64a, 63b, and 64b are displayed. In Fig. 1 which is a plane view, four slopes 64a~64d of the cathode layer 5 are displayed.  
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[0060] Configuration and forming method of the organic luminous layer 4 and the cathode layer 5 are the same as in the first embodiment except for setting the thickness of the organic luminous layer 4 to 100 nm. Namely, in this embodiment, the thickness of the organic luminous layer 4 is set to 100 nm, and the thickness of the convex section 32 is set to 200 nm which is larger than this. By this, the protruding height h of the organic luminous layer 4 by the slope 63 is set to be larger than the thickness of the organic luminous layer 4.  
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[0061] Therefore, according to the organic electroluminescence element of this embodiment, light H generated in the organic luminous layer 4 and irradiated in parallel to the cumulate surface of the cumulate body S is mainly reflected by the slope 63 which is a boundary between the cathode layer 5 and the organic luminous  
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layer 4 and goes out to the anode layer (a light-transmissive electrode layer) 3 side. By this, outgoing efficiency of light generated in the organic luminous layer 4 to the anode layer 3 side can be increased without decreasing the numerical aperture. Here, by setting slope 63 to  $45^\circ$ , quantity of light that is reflected by this slope 63 and goes out to the anode layer 3 side can be maximized.

[0062] Also, in this organic electroluminescence element, because both of the electrode layers 3 and 5 and the organic luminous layer 4 have slopes that exist over the whole surface in the pixel region, areas of the two electrode layers 3 and 5 and the organic luminous layer 4 increase and the emission quantity increases by that amount compared with organic electroluminescence elements equipped with cumulate bodies whose whole surface of the cumulate layer is flat.

[0063] Further, in this embodiment, formation of the convex section 32 made of ITO for forming slopes is done by forming the first ITO film by the sputtering method, forming the second ITO film over it by the liquid coating method, and patterning this. Here, because the ITO film formed by the liquid coating method has a larger etching speed than the ITO film formed by the sputtering method, it is difficult for the underlying, first ITO film to be overetched.

[0064] By this, the protruding height of the convex section 32 can be easily made the same with the thickness of the second ITO film. Therefore, by forming the second ITO film to the same thickness with the protruding height of the convex section 32, the protruding height of the convex section 32 can be easily controlled.

[0065] By the way, in this embodiment, although light is extracted from the ITO electrode side which is the anode 3, another arrangement can also do where the anode and the cathode are exchanged. For example, even if a metallic anode with high light reflecting efficiency is used as the cathode layer 5 of this embodiment, and corresponding to this, even if a thin film metallic cathode with high light transmitting efficiency, for example, is used as the anode layer 3, light can be extracted efficiently as well.

[Fourth Embodiment]

[0066] Using Figs. 5 and 6, an explanation is given on an organic electroluminescence display corresponding to the fourth embodiment of the organic electroluminescence element of the present invention. Figure 5 is a plane view showing an area (an area corresponding to the pixel region divided by the bank 17 in

Fig. 11) of this organic electroluminescence display, and Fig. 6 corresponds to the cross sectional view of the A-A line in Fig. 1.

[0067] The code 1A in Fig. 6 indicates a glass substrate in the state just before a cumulate body S is formed (a state where many kinds of driving elements are formed on the glass substrate and the bank 17 is formed).

[0068] In this embodiment, in the same way as the third embodiment, slopes 62~64 of both electrode layers 3 and 5 and an organic luminous layer 4 are formed by making an anode layer (a light-transmissive electrode layer) 3 made of ITO ( $\text{In}_2\text{O}_3$ - $\text{SnO}_2$ ) in a shape having a convex section 32 corresponding to the slopes. However, while one convex section 32 is formed in one pixel region in the third embodiment, sixteen convex sections 32 are formed in one pixel region in this embodiment. The rest of the configuration is the same as with the third embodiment.

[0069] Namely, in this embodiment, patterning of the second ITO film is done so that sixteen convex sections 32 having four slopes 62 are formed in a rotational symmetry centering on the central point O of one pixel region. Then, on the anode layer 3 having these convex sections 32, an organic luminous layer 4 and a metallic cathode layer (a light-reflective electrode layer) 5 are formed one by one.

[0070] Thus, slopes 63 and 64 are formed on the section of four slopes 62 of the convex section 32 on the organic luminous layer 4 and the cathode layer 5, too. These slopes 62~64 protrude from the anode layer 3 side to the cathode layer 5 side. Also, as shown in Fig. 5, if one pixel region of this display is seen from the cathode layer 5 side, sixteen projections 7 having four slopes 64a~64d of the cathode layer 5 as its sides and one plane 64e as its top are formed in a rotational symmetry centering on the central point O of one pixel region.

[0071] Namely, in this embodiment,  $16 \times 4$  sets of slopes are arranged uniformly in the surface of one pixel region. By this, slopes 63 which reflects light generated in the organic luminous layer 4 and irradiated in parallel with the cumulate surface of the cumulate body S to let it go out toward the anode layer 3 side are arranged uniformly in the surface of one pixel region.

[0072] Therefore, in this embodiment, it has an effect that uniformity of brightness inside one pixel region becomes higher compared with the third embodiment where slopes are formed only in the rim section sides of one pixel region.

**[0073]** Being a method of arranging plural number of slopes uniformly in the surface of one pixel region, examples different from the one in Fig. 5 are shown in Figs. 7 and 8. Figure 7 (a) is a plane view showing an example of the arrangement method, and Fig. 7 (b) is a cross-sectional view of the B-B line in Fig. 7 (a). Figure 8 (a) is a plane view showing an example of the arrangement method, and Fig. 8 (b) is an expanded view showing the details of a projection 7 in Fig. 8 (a).

**[0074]** In the arrangement in Fig. 7, as shown in Fig. 7 (a), a frame-shape projection 71 formed with a specified width consisting of two similar squares forming a pixel region is installed in the rim section of the pixel region, and a similar frame-shape projection 72 is also installed inside this. In this case, as shown in Fig. 7 (b), four slopes 64a and 64b by projections 71 and 72 are formed between the central point O and the rim section of one pixel region.

**[0075]** Here, because Fig. 7 (b) is a cross-sectional view of one body of the cumulate body S and the glass substrate 1A, only the slopes 64a and 64b of the cathode layer 5 on the very top are displayed in this figure.

**[0076]** In the arrangement in Fig. 8, sixteen projections 7 having four slopes 64a~64d of the cathode layer 5 as its sides and one plane 64e as its top are formed in a rotational symmetry centering on the central point O of one pixel region. The planar shape of the projection 7 is not limited to a rectangle as in this figure or a square in Fig. 5 but can be a circle etc. If the case where the planar shape of the projection 7 is a circle is compared with the case where it is a rectangle or a square, the circle case has higher uniformity of brightness within one pixel region.

**[0077]** Here, although the cumulate body in each of the embodiments consists of a light-transmissive electrode layer on the substrate side, an organic electroluminescence element equipped with a cumulate body having a light reflecting electrode layer on the substrate side is also included in the present invention. In an electroluminescence element equipped with a cumulate body having a light-reflective electrode layer on the substrate side, when installing a projection made of an insulating material between the electrode layer on the substrate side and the substrate, this projection does not need to be light-transmissive.

**[0078]** Also, although an explanation is given on an organic electroluminescence display in each of the embodiments, the present invention is not limited to this but can be applied to other organic electroluminescence elements such



as planar light source . In the case of a planar light source, it is effective to increase uniformity of brightness within the luminous layer by forming plural number of slopes uniformly arranged in the luminous surface as in the fourth embodiment.

5 [0079] Furthermore, whether the driving method of an organic electroluminescence display is the active matrix method or the passive matrix method, the present invention can be applied optimally. In the case of the passive matrix method, because the overlapping part of the two electrode layers becomes the pixel region, in the part where the two electrode layers overlap, a slope protruding from the light-transmissive electrode layer side to the light reflecting electrode layer side.

10 [Efficacy of the Invention]

[0080] As explained above, according to the organic electroluminescence element of the present invention, in an organic electroluminescence element equipped with a cumulate body having a cathode layer, an anode layer, and an organic luminous layer between the two electrode layers where one electrode layer is light-transmissive and the other electrode layer is light-reflective, outgoing efficiency of light generated in the organic luminous layer can be increased without decreasing the numerical aperture.

15 [0081] As a result, an organic electroluminescence element that has a high brightness and is superior to the prior art technology in low electricity consumption can be obtained.

20 [0082] Also, according to the manufacturing method of the present invention, the organic electroluminescence element of the present invention can be manufactured easily.

## [Explanation of the labels]

- 1: Glass substrate
- 1A: Glass substrate
- 2: Projection made of an insulating material
- 5 3: Anode layer (light-transmissive electrode layer) made of ITO
- 4: Organic luminous layer
- 5: Anode layer (light-reflective electrode layer)
- 7: Projection
- 10: Scanning line
- 10 11: Signal line
- 12: Common line
- 13: Switching transistor
- 14: Capacity
- 15: Driving transistor
- 15 15a: Source/drain electrode
- 16a: Contact hole
- 16: Insulating layer
- 17: Bank
- 18: Connecting plug
- 20 31: First ITO layer (First thin film)
- 32: Convex section made of ITO
- 61: Slope of projection made of an insulating material
- 62: Slope of a boundary between an anode layer and an organic luminous layer
- 63: Slope of a boundary between an organic luminous layer and a cathode layer
- 25 64a~64d: Slope of a cathode layer
- 64e: Plane of a cathode layer
- 71: Projection
- 72: Projection
- E: Organic electroluminescence element
- 30 H: Parallel irradiated light
- h: Protruding height of an organic luminous layer
- O: Central point of one pixel region
- S: Cumulate body